The Economic Impact of the COVID-19 Pandemic:

Quantifying the Damages to the Missouri Economy

A report by

Joseph H. Haslag, PhD

Executive Summary

Beginning in March 2020, the SARS-CoV-2 virus and the pandemic that followed significantly affected economic activity in the United States. The key feature is March 11, 2020. After that date, the facts indicates that the SARS-CoV-2 virus spread widely across the United States, resulting in efforts to control the spread, including masks, business shutdown, and employment losses. According to Paragraph 6 of the Petition, the Defendants—the Peoples Republic of China—in violation of their duties to the international community, engaged in dangerous activities that imperiled the lives and health of millions. Paragraph 15 goes on to state that: "As a sovereign State, Missouri has 'a quasi-sovereign interest in the health and well-being—both physical and economic—of its residents in general.' "

The purpose of this report is to quantify the economic damages suffered by the citizens of the State of Missouri and the State of Missouri Government due to the outbreak of the diseases caused by the SARS-CoV-2 virus.

The findings are summarized as follows:

- The economic impacts are divided into contemporaneous effects and future effects. The contemporaneous effects are captured by comparing the actual path of real GDP in Missouri with the control path constructed "as if" the SARS-CoV-2 virus had not occurred. The difference between the two paths is the quantitative measure of the impact that the pandemic had between March 2020 and May 2023.
- SARS-CoV-2 also affected future economic activity by hindering education. There is evidence from standard tests that math and reading attainment was close to one-half year because of the disruptions to K-12 education. The University of Pennsylvania projects the impacts on labor productivity between 2021 and 2051. The projected labor productivity growth losses are applied to control path for Missouri real GDP from 2023 through 2051.
- For the contemporaneous economic damages, the cumulative sum of Missouri GDP losses is $23.21 billion during the period 2020 Q1 and 2023 Q2.
- For the future economic damages, the cumulative, discounted sum of GDP losses in Missouri are $480.24 billion between 2024 and 2051. Thus, the total economic damages to the State of Missouri are $503.4 billion between 2020 and 2051.
- Research conducted by University of Southern California report contemporaneous economic damages for the United States. Based on the University of Southern California estimates, the share of the Missouri economic damages are equal to $216.42 billion between 2020 and 2024.
- The dollar value of economic damages is calculated to be $503,446,370,000. If we use the estimates from the University of Southern California, the total economic damages would be $696,658,620,000. Real GDP serves as the tax base for the State of Missouri. Because of the economic damages, the State of Missouri General Fund would be no less $15.61 billion lower because of the SARS-CoV-2 virus. At the high end of the economic damages to the Missouri tax base, the foregone General Revenue Funds could be as high as $21.6 billion.

Introduction

In the report, I offer an expert opinion on the economic damages in the case involving The State of Missouri (hereafter the Plaintiff) v. the People's Republic of China, the Communist Party of China, the National Health Commission of the People's Republic of China, the Ministry of Emergency Management of the People's Republic of China, the Ministry of Civil Affairs of the People's Republic of China, the People's Government of Hubei Province, the People's Government of Wuhan City, the Wuhan Institute of Virology and the Chinese Academy of Sciences (hereafter, the Defendants).

The case centers on transmission of the SARS-CoV-2 virus (hereafter Covid-19 virus) and the pandemic that followed. The key feature in the case occurs on March 11, 2020. According to Paragraph 6 of the Petition, the Defendants, in violation of their duties to the international community, engaged in dangerous activities that imperiled the lives and health of millions. Paragraph 15 goes on to state that: "As a sovereign State, Missouri has 'a quasi-sovereign interest in the health and well-being—both physical and economic—of its residents in general.'"

The purpose of this report is to quantify the economic damages suffered by the citizens of the State of Missouri and the State of Missouri Government due to the outbreak of the diseases caused by the SARS-CoV-2 virus

The Facts

The Covid-19 pandemic affected economic activity across the world and over time. The World Health Organization (WHO) declared the start of the Covid-19 pandemic beginning March 11, 2020, and ending on May 5, 2023. The economic impacts were not limited to this period. As governments implemented actions to mitigate the spread of the disease, investments in human capital were also affected. Researchers at the University of Pennsylvania argued that reading and math achievement showed the equivalent of 0.4 years of schooling. Without correction, students in the 2020-21 academic year will be permanently affected. With education and future productivity positively correlated, the lost investment in human capital will affect economic activity for the remainder of these student's work lives.

The purpose of this report is to quantify the economic impact that the Covid-19 pandemic had on the State of Missouri economy. Two sets of calculations are performed. First, compute the economic impacts during the period of the pandemic. The idea is that the Missouri economy would have continued along its average trajectory. What actually transpired is an L-shaped recovery. The losses during the pandemic represent the difference between the measure of what would have happened (the Control) and what actually happened (the Treatment).

Second, the pandemic has impacts that persisted because of the effects on investment. In particular, human capital investment was affected with estimates that K-12 students lost approximately 0.4 of a school year to the pandemic. The post-pandemic effects are measured over the period from 2023 through 2051. Future losses are discounted to bring them to the value in 2023.

During the pandemic, the calculations indicate that the Missouri economy lost more than $23 billion in GDP between 2020:Q1 and 2023:Q2. Between 2023 and 2024, the sum of discounted GDP losses in Missouri are projected to be over $480 billion. Combined the projected GDP losses in Missouri are just over $500 billion in 2023 inflation-adjusted dollars. In terms of lost revenues paid to the State of Missouri, the discounted sum of foregone revenues is equal to $15.61 billion for the period 2020 through 2051.

Methods and Analysis

In this report, aggregate economic measures of real Gross Domestic Product (GDP) are the basis for comparing measures of what actually happened during and after the Covid-19 pandemic and what would have happened if no pandemic had occurred. By its encompassing nature and because it is measured in dollars (adjusted for inflation), GDP is the natural metric for quantifying the total impact of events, like the pandemic, on economic outcomes.

Since the 1930s, researchers have characterized economic outcomes as reflecting impulses and the subsequent propagation mechanisms. To illustrate, a pebble dropped into a pool of water is analogous to the impulse hitting the economy. Propagation describes how the waves move through the pool over time. In the pool, the propagation depends on how deep the pool, any rocks or underwater plants (frictions) that impede the waves. In an economy, frictions include legal restrictions and regulations, access to markets, hidden information or actions by market participants, along with a host of other factors.[1]

For the purposes of this report, we identify the Covid-19 pandemic as the impulse that affected the Missouri economy. In addition to the immediate impact, the Missouri economy continued to be affected as the impulse propagated through the economy over time. To quantify the economic impact, we take the observed path of the Missouri economy From March 2020 forward as the Treatment effect; that is, we know what actually happened to the Missouri economy after the Covid-19 virus was introduced into the Missouri economy, at least through the end of 2023. To consider the Treatment effect after 2023, we rely on measures calculated from the Budget Model maintained at the University of Pennsylvania.[2]

In addition, we need a control path for the Missouri economy. Here, the term Control refers to a measure of what Missouri's GDP *would have been* without the impulse coming from the Covid-19 virus. In our setup, Control path is constructed as if the Missouri economy would have increased at its average annual growth rate. The underlying assumption is that impulses are, on average, not predictable. More precisely, the expected value is distributed with mean zero and constant variance. The actual draw form the distribution of impulses is not necessarily equal to zero. The point is that the expected value of the actual draw is equal to zero before it happens.

With the construction of the Control path and the Treatment path, the economic damages are the difference between the two. With Covid-19, we will see that Missouri's real GDP declines in response to the impulse. Over time, as the Covid-19 effects continue to propagate through the Missouri economy, we continue to see declines in Missouri's GDP relative to the Control path.

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[1] It is outside the scope of this report to identify all the different frictions that operate in the economy. The use of impulse-propagation language can be traced back to a statistician and to an economist. For the interested reader, the statistician Yule, G. U. (1926), "Why do we sometimes get nonsense-correlations between time series?: A study in sampling and the nature of time series," *Journal of Royal Statistical Society*, 89, 1-64; and the economist, Frisch, R. (1933), "Propagation problems and impulse problems in dynamic economics," in *Economic Essays in Honor of Gustav Cassell*, London: Allen & Unwin, 171-205 independently came to the characterization that time series data can be characterized with the impulse-propagation analogy.

[2] There will be a detailed description and source presented in the section that describes the specific methodology used to construct the post-2023 Treatment effect.

1. **Economic Damages**

   a. **Damages during the pandemic**

The first step is to compute the economic damages that affected the Missouri economy during the pandemic. The World Health Organization (WHO) declared the start of the pandemic identified as Covid-19 as March 11, 2020. The WHO declared the pandemic ended on May 5, 2023.

Thus, we measure the difference between Missouri's GDP Control path and its Treatment path for the period between March 2020 and May 2023. Because GDP is reported at quarterly frequencies, we focus on GDP starting in 2020 Q1 and ending in 2023 Q2. (Throughout this report, I adopt the notation shorthand: Q2 refers to the second quarter in the year.)
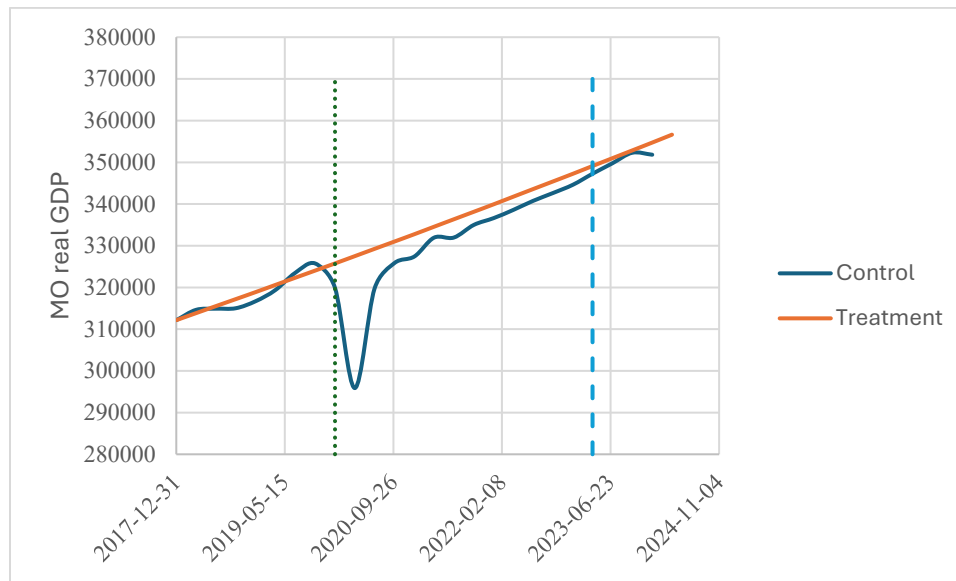
The Control path is constructed using the projected value of Missouri's GDP in the absence of any impulses during the 2020 Q1 through 2023 Q2 period. To calibrate the projected Control path, we use the average annual percentage change in Missouri GDP for the period 2018 Q1 through 2019 Q4. From these data, we see that the Missouri GDP increased at a 2.15 percent average annual rate. The Control path is initiated at $312.18 billion which is the level observed in 2018 Q1. Figure 1 plots the observed (Treatment) and the projected (Control) path for Missouri GDP for the period 2018:Q1 through 2024:Q4. The two vertical lines represent the dates at which the Covid-19 pandemic started and ended.

From Figure 1, we see there was a small drop in Missouri GDP in the first quarter of 2020. As mitigation efforts were implemented, there is a sharp decline in the second quarter of 2020. By the third quarter of 2020, Missouri GDP is rebounding. It continues to approach the Control path from 2021 through 2023. In each quarter, the economic damage is measured as the vertical distance between the orange (Control) path and the blue (Treatment) path. Note that the data in Figure 1 are the quarterly values that have been annualized. To compute the quarter-by-quarter damages during the pandemic, we divide these annualized values by four.

Figure 2 has performed the conversion to lost Missouri GDP quarter-by-quarter. Based on these calculations, Missouri lost nearly $1.5 billion in GDP during the first quarter of 2020. As the United States implemented more restrictions in order to mitigate disease spread, the lost GDP jumped in the second quarter of 2020, increasing to $8 billion. It was not until the third quarter of 2021 that Missouri's lost GDP fell below $1 billion. To obtain the cumulative sum of economic damages, we multiply each

Figure 1

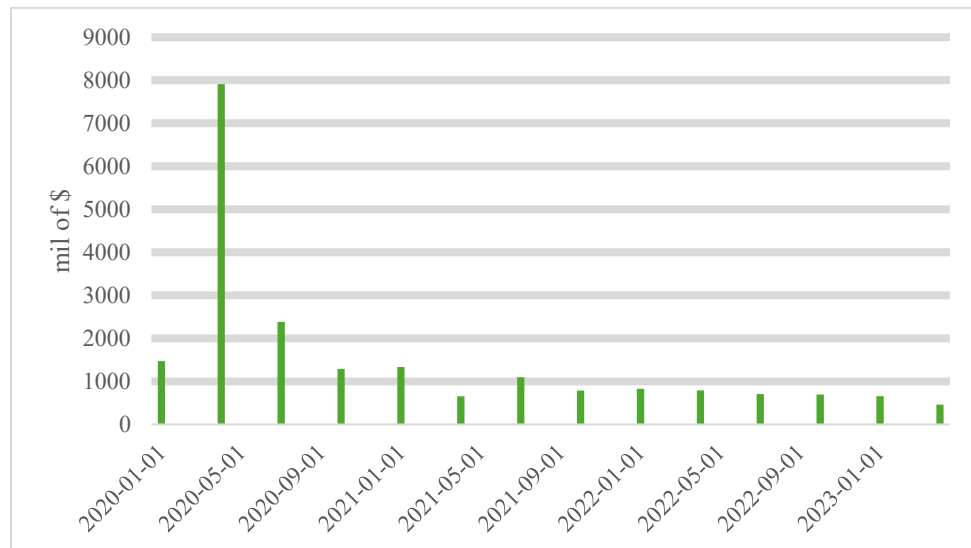**Control and Treatment levels of Missouri GDP, 2018-2024**

quarter's value by the Treasury bill rate for each quarter between 2020 Q1 and 2023 Q2.[3] We adjust the losses in Missouri real GDP suffered between 2020:Q1 and 2023:Q2. The adjustment could have been done using the average real return on a portfolio of investments. Instead, we use a very conservative return, which is the risk-free return on United States Treasury securities. The Treasury bill rate converts the current period GDP loss to what it would be worth—principal plus interest—in 2024 Q4. To illustrate, in 2022 Q3, the quarterly average annual return was 2.93 percent for Treasury securities maturing in 2024 Q4. With Missouri's lost GDP equal to $707.14 million (the principal) in 2022 Q3, I multiply the 2022 Q3 principal by the annual return raised to the power 2.25 because there is 2 years and one quarter between 2022 Q3 and 2024 Q4.

After adjusting for interest on the economic damages, the cumulative sum of Missouri GDP losses is $23.21 billion during the period 2020 Q1 and 2023 Q2.

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[3] We obtained those data from the Federal Reserve Bank of St. Louis FRED database. The values are reported in the data appendix to this report.

Figure 2

Quarterly Value of Damages to Missouri GDP
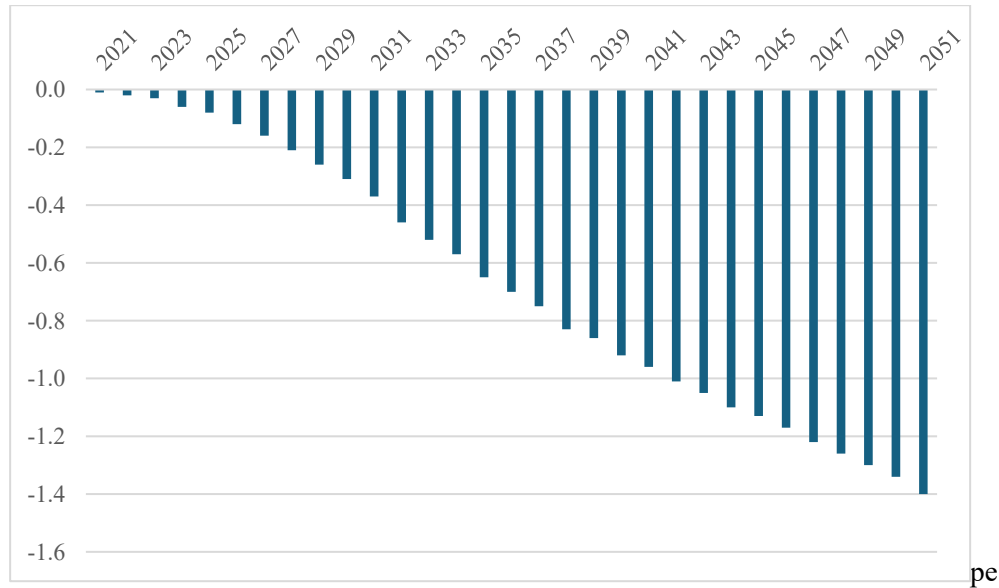

b. **Damages after pandemic**

In order to mitigate the spread of Covid-19, government responses included measures that affected public education. The disruption to K-12 education is projected to impact future productivity. Consequently, measures of treatment effects after May 2023 are included.

To estimate the impact on future productivity, estimates are obtained from the Budget Model created at the University of Pennsylvania (hereafter the Penn Wharton model). Based on reading and math test scores, the Northwest Evaluation Association (NWEA) student learning gains during the 2020-21 school year.[4] The Penn Wharton model converts the grade-specific achievement scores into a projected loss of effective years of schooling by comparing actual scores that would have been achieved without the disruption to K-12 education. The next step is to use estimates of the effects of years of education and future worker productivity. The Penn Wharton projections are that students lost roughly 0.4 school years of reading and math education during the 2020-21 school year.

With less effective school years, the Penn Wharton model projects the annual impacts on economic growth in the United States. Figure 3 plots the projected impact on real GDP growth for the period 2021-2051. The data show that the impacts are initially quite small—less than 0.1 percent—through 2025. The rationale is that only a few students will enter the workforce immediately after the 2020-21 school year.

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[4] See "COVID-19 Learning Loss: Long-run Macroeconomic Effects Update," Penn Wharton Budget Model, University of Pennsylvania. The report can be found at COVID-19 Learning Loss: Long-run Macroeconomic Effects Update — Penn Wharton Budget Model . The NWEA report can be found at Learning-during-COVID-19-Reading-and-math-achievement-in-the-2020-2021-school-year.research-brief-1.pdf.

Figure 3

However, the projected losses increase over time due to two factors. First, number of workers affected will be completely absorbed into the workforce over time. Second, there is a compounding effect that owes to the productivity losses over time. Indeed, by 2051, the projected loss is 1.4 percent of GDP.

To estimate the future impacts on the Missouri economy, we apply the national projected percentage loss in real GDP to Missouri's future path of real GDP. We construct losses for the period 2023-2051. The Control path for Missouri's future real GDP is constructed by applying the average annual percentage change to the base year level of GDP in 2023.

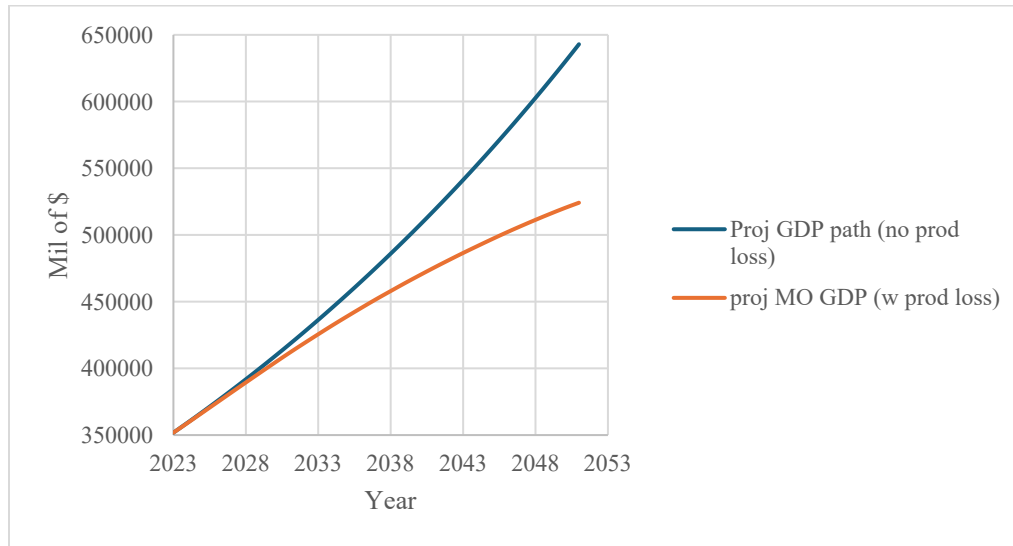$$Y_t^c = (1 + 0.0218)\, Y_{t-1}^c \qquad (1)$$

for $t = 2024,\ 2025,\ \ldots,\ 2051$. Note that Y_{2023}^c is the initial value. Equation (1) starts with the assumption that Missouri real GDP increased at a 2.18 percent average annual rate from 2018 through 2023.

To construct the Treatment path, we modify equation (1) to take into account the percentage change in economic growth projected for each year by Penn Wharton model. Let l_t $t = 2024,\ 2025,\ \ldots, 2051$ denote the economic growth rate loss in each year from 2024 through 2051. Next, subtract the projected GDP growth loss from 2.18 percent where l_t is taken from Figure 3. The result is the projected annual percentage change in Missouri real GDP. Formally, we write

$$Y_t^p = \left(1 + \left(0.0218 - l_t\right)\right) Y_{t-1}^p. \qquad (2)$$

As we had in Equation (1), the initial value is Missouri real GDP in 2023. The economic impact is presented as the difference between the control value and the Treatment value for each year from 2024 through 2051. Figure 4 plots the two paths. By 2051, the difference is nearly $120 billion a year.

Figure 4

If we simply accumulate the annual losses, the value is over $1 trillion between 2024 and 2051. In order to compare future losses to the present value, I discount all future losses, using a discount rate of four percent.[5] The cumulative, discounted sum of GDP losses in Missouri are $480.24 billion between 2024 and 2051.

c. Total damages

Between 2020 and 2051, Table 1 presents the projected value of economic damages to the State of Missouri. The projected losses are divided, presenting those during the pandemic period and those after the pandemic that reflect productivity losses due to loss of school years. Based on the calculations presented here, the total losses in real GDP amount to over $500 billion.

d.   Revenue losses paid to State of Missouri

Between 2019 and 2023, the State of Missouri collected 3.1 cents per dollar of GDP. We apply this ratio to compute the foregone revenues that would have been collected by the State of Missouri for the period starting in 2020 and ending in 2051. The discounted sum of foregone revenues is simply the product of GDP losses and 0.031. Thus, the discounted sum of foregone revenues paid to State of Missouri government is $15.61 billion.

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[5] The discount rate for any future year, therefore, is $(1 + 0.04)^{-(t-2024)}$ where t stands for the future date from 2025 through 2051.

Table 1

Projected Losses in Missouri real GDP, 2020 – 2051

Period	Economic Loss to Missouri
2020:Q1 - 2023:Q2	$23,207.75
2024- 2051	$480,238.62
	$503,446.37

2. Other estimates

In a paper by economists at University of Southern California (USC), the economic impact of the Covid-19 pandemic was estimated over the period 2020:Q1 through 2023:Q4.[6] Using a Computable General Equilibrium model modified to deal with the economic impacts of a natural disaster, the researchers estimated the impact was lost GDP equal to $14 trillion over the four-year period.

To estimate the impact borne by Missouri, we assume the losses are proportional to the state-level GDP. Between 2018:Q1 and 2024:Q2, Missouri's real GDP was 1.55 percent of the national level. Under the assumption of proportional losses, the USC projections would project that Missouri lost $216.42 billion between 2020 and 2023. The USC estimates are nearly ten times the projections reported using a Control and Treatment approach used in this report. For the sake of completeness, we include these estimates because they are generated using a more sophisticated modelling approach to construct the Control path for the economy. Combined with the economic growth impacts due to the school-year losses during academic year 2020-21, the discounted sum of total economic damages would be $696.66 billion for the period 2020 through 2051.

Note that if Missouri's lost real GDP is equal to $216.42 billion, then the lost State of Missouri collections to General Revenue would be $6.71 billion between 2020 and 2023. The discounted sum of State of Missouri revenue losses would be $21.6 billion between 2020 and 2051.

Total Economic Damages

Now that each component of the economic damages has been calculated. Table 2 reports the total economic damages between March 2020 and December 2051. The dollar value of economic damages is calculated to be $503,446,370,000. If we use the estimates from the University of Southern California, the

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[6] See Walmsley, Terrie, Adam Rose, Richard John, Dan Wei, Jakub P. Hlávka, Juan Machado, and Katie Byrd, (2023). "Macroeconomic Consequences of the COVID-19 Pandemic," *Economic Modelling*, 120. The authors report that U.S. real GDP would have totaled $117 trillion over the four-year span. Real GDP was only $103 trillion.

total economic damages would be $696,658,620,000. Lost revenues to the State of Missouri General Fund would be no less $15.61 billion and could be as high as $21.6 billion.

Witness' Qualifications

Dr. Joseph H. Haslag is Professor and Kenneth Lay Chair in Economics at the University of Missouri-Columbia. Professor Haslag received his PhD in Economics from Southern Methodist University in 1987. Professor Haslag spent 12 years in the Research Department at the Federal Reserve Bank of Dallas, teaching undergraduate and graduate courses at Southern Methodist University. He visited the Economics Department at Michigan State University in 2000 and the Department of Monetary Economics at Erasmus University in 1994. He has been a visiting scholar at the Federal Reserve Banks of St. Louis, Kansas City, Atlanta, and Cleveland. He has published his research in such prestigious academic journals as the *Journal of Monetary Economics*, *The Review of Economics and Statistics*, *Journal of Money, Credit, and Banking*, *International Economic Review* and the *Review of Economics Dynamics*, among other leading scholarly publications. His textbook on monetary economics, co-authored with Scott Freeman and Bruce Champ is in its 5th edition. Professor Haslag is under contract with Wiley Press to write an intermediate-level textbook on macroeconomics with Dr. Chris Otrok. According to Google Scholar, Dr. Haslag's work has been cited over 1,690 times.

At the University of Missouri, Joe has also been the Executive Director of the Economic and Policy Analysis Research Center until 2021. Joe continues to serve the State of Missouri, serving as the external member of the State's Consensus Revenue Forecasting team. He has been a member of the Federal Reserve Bank of Kansas City's Business and Economic Research Group.

Since 2014, Dr. Haslag has published ten research papers (listed below):

1) "Is the Funding Fee Enough? A Quantitative Analysis of the VA Mortgage Program," *International Journal of Social Science and Economic Research*, July 2022, 7(7), 2178-2216.

2) "Modeling Uncertainty: Two Approaches in a Model with Heterogeneous Forecasts (joint with William A. Brock), *The Singapore Economic Review*, June 2022, 67(4), 1389-1420.

3) "On the Economic Impacts of Transportation Innovations: A Comprehensive Application to Quantifying the Impacts of a Hyperloop Technology," *The Economics and Finance Letters,* May 2022, 110-124..

4) "Monetary and Fiscal Policy Interactions in a Frictional Model of Money, Nominal Debt, and Banking," *European Economic Review*, 139, October 2021.

5) "On Phase Shifts in a New Keynesian Model Economy," (joint with Xue Li), *Macroeconomic Dynamics*, December 2021, 25(8), 2080-2101.

6) "Computing State Average Marginal Income Tax Rate: An Application to Missouri," (joint with G. Dean Crader) *Growth and Change: A Journal of Urban and Regional Policy,* November 2018, 50(1), 424.45.

7) "Do Payment Systems Matter: A New Look," (joint with Jim Dolmas) *Journal of Finance and Economics,* March 2018, 9(1), 1-25.

8) "A Tale of Two Correlations: Evidence and Theory Regarding the Phase shift between the Price Level and Output," (joint with William A. Brock) *Journal of Economic Dynamics and Control*, June 2016, 67, 40-57.

9) "Government Policy under Price Uncertainty: A Source of Volatility in Illegal Immigration" (joint with Mark Guzman and Pia Orrenius), *Canadian Journal of Economics,* August 2015, 48(3), 940-962.

10) "Unconventional Optimal Open Market Purchases," (joint with Chao Gu), *Review of Economic Dynamics*, July 2014, 17(3), 543-58.

11) *Modeling Monetary Economies*, 5th Edition, Cambridge University Press, 2023.

List of Expert Testimonies (4 Years):

1) Baker v. Martin Leigh (for defense), 2023
2) Ainsley Rice, et al v. Richard Gutknecht, MD (for defense), 2018
3) Heck and Harper v. Congruex (for defense), 2021
4) Hemphill v. St. Luke's Hospital (for defense), 2022
5) Northland Management & Construction, LLC v. the City of Parkville, Missouri (for Plaintiff), 2024.

Fee Schedule

My compensation for research and testimony is $400 per hour.